Modeling and Predicting Driver Behavior in ACT-R

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The ACT-R driver model represents a novel approach to modeling driver behavior in a cognitive architecture. The ACT-R architecture [1], like similar production-system architectures, includes numerous built-in, well-tested predictions concerning the parameters and constraints of cognition (e.g., memory and forgetting effects, errors) and visual-motor performance (e.g., manual control actions, eye movements). By developing a model of driving in a cognitive architecture, the model inherits all the cognitive and visual-motor predictions of the architecture and allows for more psychologically plausible models of behavior. In addition, the driver model produces quantitative predictions that can be compared directly to observed human driver behavior. The model thus allows for both theoretical understanding of driving behavior and practical design and development of real-time systems.

Our work with the ACT-R driver model [4] currently focuses on two primary branches of work. First, we are developing a driver model that faithfully represents behavior in a highway driving environment, emphasizing the integration of the lane keeping, curve negotiation, and lane changing subtasks. The model is based on a conceptual hierarchical driver modeling framework [2] that characterizes the interaction between operational and cognitive information processing. Operational control involves lane keeping, speed regulation, and headway regulation. These are modeled by the perceptually plausible two-level control model. The cognitive processes are responsible for maintaining situation awareness, deciding when to initiate and terminate maneuvers, as well as manage other tasks that are not immediately relevant to the primary driving task (e.g. enjoying the environment or talking on a cell phone). These are characterized by specifying the important input information as well as the various payoff structures for the tasks involved and letting the ACT-R architecture constrain the interaction between these cognitive processes. We compare the predictions of the model to data collected in a highway-driving experiment in our fixed-based simulator. Eye movements were monitored in our experiments and used as a rational surrogate for attention shifts. Results show that the model is capable of predicting attentional demands and reproducing drivers' attention shifts before and during lane changes as well as during the various phases of curve negotiation.

The second primary branch of work is the *a priori* prediction of driver distraction due to secondary in-vehicle devices. This work relies on the integration of the driver model with a user model of interaction with the secondary device. The multitasking between the driving and secondary tasks produces adverse effects on the driving task (and vice-versa). We have validated this approach in two studies examining the effects of cellular-telephone dialing on driver performance [3, 5]. The current line of work is moving toward fuller environments for (reasonably) novice users that facilitate rapid specification, modeling, and testing of new prototype devices with respect to driver distraction.

References

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